Unit #3
Atoms / Atomic Structure / Subatomic Particles
Instructor's notes

1) **Atom-** smallest particle of an element that has the chemical and physical properties of that element.
   a) Example: anything on the periodic table.

2) **Molecule-** smallest particle of a substance that is composed of at least two atoms, (they may be alike or different), and has the chemical and physical properties of that substance.
   a) Example: O_2, H_2, H_2O, CO_2, $C_6H_{12}O_6$

3) Remember from last unit, what is a (ask about both of the following properties):
   a) **Chemical property-** The ability of a substance to undergo a chemical reaction (a change) and form a new substance with new, unique properties.
   b) **Physical property-** quality or condition of a substance that can be observed or measured without changing its composition. The value does not change with the amount of substance.
      Examples: Density, Boiling / Condensation point, Melting / freezing point, color, state, odor, texture, solubility, hardness.

4) **Diatomic-** any molecule composed of only two atoms.
   a) **"BrINClHOF"-** a "word" used to remember the seven elements that are always diatomic when found free, (not combined with any other element(s)), in nature. It represents the chemical symbol for each of the indicated elements.
      What elements are indicated? Bromine, Iodine, Nitrogen, Chlorine, Hydrogen, Oxygen, and Fluorine.

5) **Polyatomic-** any molecule (or ion, as we will learn in unit #5) composed of three or more atoms.
   a) Example: H_2O, CO_2, $C_6H_{12}O_6$

6) Remember from last unit, what is a compound?:
   a) **Compound**- chemical combination of elements. Each has its own unique and identifiable characteristics. Cannot be separated by physical means. Can be separated by chemical means. Example: Na is explosive when wet. Cl_2 is a poisonous gas. When combined, they produce the compound known as "table salt".

Atomic Theories.

7) **Dalton's Atomic Theory-**

a) John Dalton (1766 - 1844 = 78 yrs. old), by age 12 he was a teacher, as he was through out his life. His real love / real genius was Science. He studied: The Aurora borealis, The Trade Winds, and Color Blindness to name a few.

b) **The Four Postulates of Dalton's Atomic Theory** are:

i) All elements are composed of submicroscopic, indivisible, particles, called atoms.

ii) Atoms of the same element are identical. The atoms of any one element are different from those of any other element.

iii) Atoms of different elements can physically mix together. This yields a Mixture. Or, they can chemically combine with one another in simple whole number ratios to form a Compound.

iv) Chemical reactions occur when atoms are:

(1) Separated

(2) Joined

(3) Rearranged

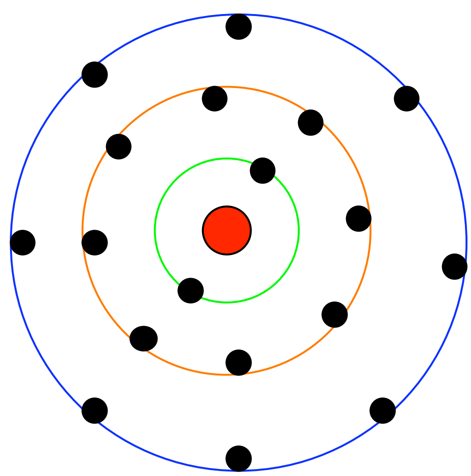
However, atoms of one element are never changed into atoms of another element as the result of a chemical reaction.

8) **Bohr's Theory of Atomic Structure-**

a) Niels Bohr (1885 - 1962 = 77 yrs. old). Danish scientist

b) Bohr believed the electrons move around the nucleus (the center) of an atom, like the planets revolve around the sun.

c) We still use this concept today, but in a modified way.



The red circle is the nucleus.
It is encompassed by the "green orbit" (first energy level) that can hold a maximum of 2 electrons.
The second energy level surrounds the first and can hold a maximum of 8 electrons.
This drawing also shows the third energy level with its maximum of 8 electrons.

We will learn there are 7 energy levels, some having up to 4 sublevels.

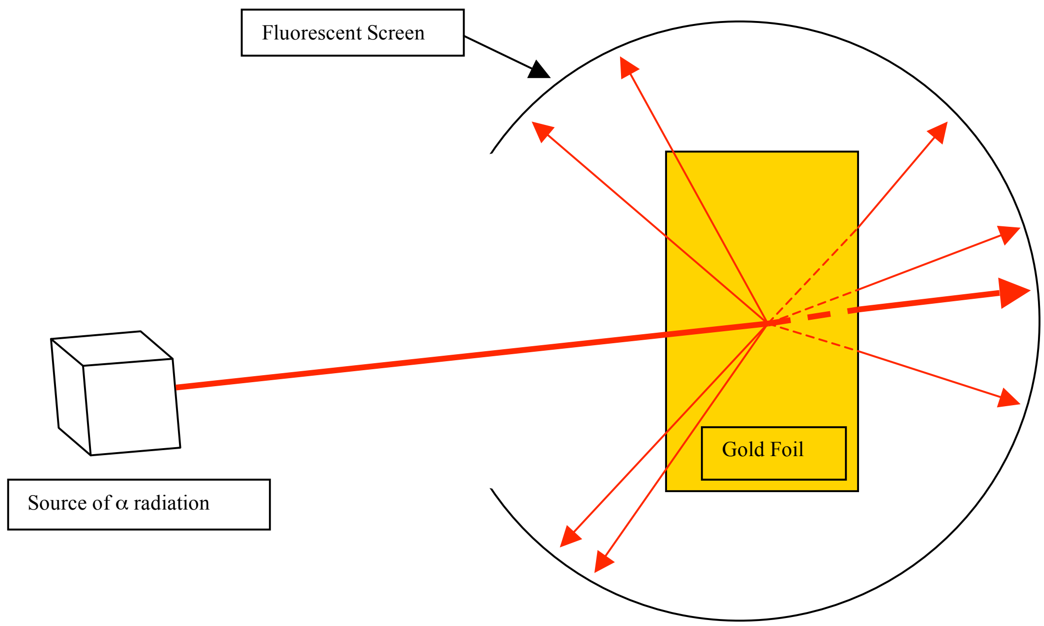
9) **Rutherford's Atomic Theory-**

a) Ernest Rutherford (1871 - 1937 = 66 yrs. old). English physicist.

b) Rutherford's experiment concluded that most of the atom must consist of space without the nucleus. The nucleus must occupy a very, very, small portion of the volume of an atom. This nucleus contains all of the mass and positive charge of the atom.

c) For comparison purposes, if an atom was the size of an NFL stadium like "Heinz Field"; the nucleus would be the size of a marble in the middle of the field.

d) His experiment involved directing a beam of alpha particles (high energy radiation) at a piece of gold foil. They had expected the radiation to pass straight through the foil. To their surprise, some of it was deflected or bounced back.



e) Your text book makes this analogy: It would be like firing a 15" artillery shell at a piece of tissue paper and having it bounce back at you.

f) The rays were deflected when they had direct hits on the nucleus of an atom.

Subatomic Particles.

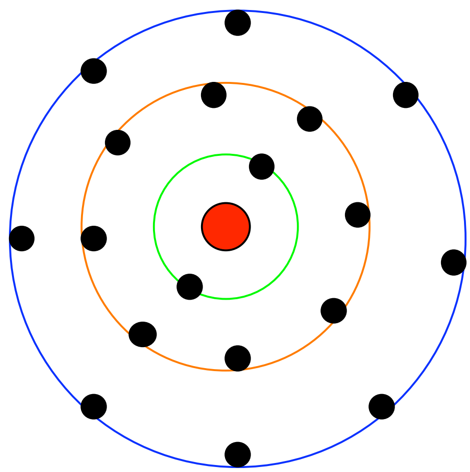
10) **Electron-** negatively charged particle (equal to -1) that orbits the nucleus with an insignificant mass. Approximately equal to $9.11 * 10^{-28}$g.

a) **Valence electron-** electrons in the outer most "shell". The maximum number of these for any atom is 8. (We will later learn that they fill the "s" & "p" sublevels in the highest energy levels).

b) **Core electron-** any electron not considered a valence electron. In between the nucleus and the outermost "shell".

c) **Electron Cloud-** area surrounding the nucleus where the electrons can be found. Both valence and core electrons are here. This area is negatively charged. Analogous to clouds surrounding the earth.

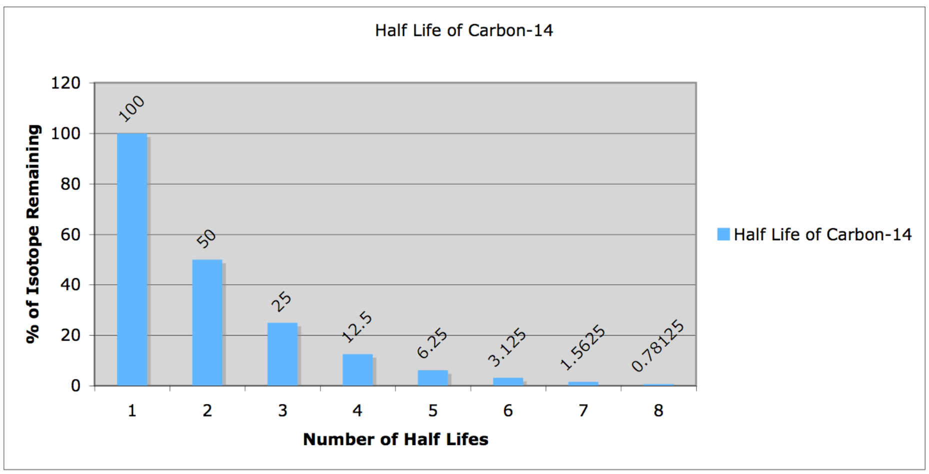
d) The number of electrons are equal to the number of protons in a neutral (uncharged) atom.
e) Refer to the diagram previously discussed during "Bohr's Atomic Theory". Which electrons are valence? The blue "orbit" is the valence. Which are core? The green and orange "orbits". What is the red "circle"? The nucleus.



11) **Nucleus-** dense positively charged center of the atom. Accounts for the mass of an atom. Contains both protons and neutrons.
   a) **Proton-** positively charged particle (equal to +1) in the nucleus with a mass of 1 AMU. Approximately equal to $1.67 * 10^{-24}$g.
      i) **Atomic number-** equal to the number of protons.
   b) **Neutron-** an uncharged particle in the nucleus; same mass as a proton.
      i) **Atomic mass-** equal to the sum of the protons and neutrons.

12) **Isotope-** atoms of the same element (therefore the number of protons and electrons) with a different number of neutrons. Often radioactive.
   i) Example: Isotopes of Hydrogen.
      (1) **Protium-** 1 proton 0 neutrons 1AMU
         (a) This is the most common form of hydrogen and is the "one" listed on the periodic chart.
      (2) **Deuterium-** 1 proton 1 neutron 2 AMU
         (a) Used to produce "Heavy water" (water with a mass of 20 AMUs vs. 18 AMUs for regular water). It is useful to determine "where" the hydrogen is coming from during a chemical reaction.
      (3) **Tritnium-** 1 proton 2 neutrons 3 AMU
         (a) Used to produce "night sights" for low light target acquisition. (Glows in the dark without needing to be exposed to light.
         Remember: A "pro" is number 1, a duet is 2 singers, and a tricycle has 3 wheels. These numbers also apply to the AMUs of the above isotopes.

ii) Example : Isotope of Carbon.
  (1) How can we tell how old a "young" fossil is? Radioactive Carbon 14 (C^{14}) dating.
  (2) The most common isotope of carbon is C^{12} , therefore it is on the periodic chart. However, C^{14} also exists in minute quantities (less than 1% of all carbon atoms are this isotope). It is incorporated into the molecules of living substances and remains there even after death (until it "decays").
  (3) **__Half-life-__** The amount of time required for 1/2 of the existing isotope to decay to the most common form of the isotope or to an atom of another element.
  (4) Scientists compare the amount of C^{14} in a living organism to what is left in a "young" (50,000 yrs. old max.) fossil. (If the fossil is older they can use K^{40} its half life is 1.3 billion years.)



  (5) Each bar in the above graph represents 1 half-life for C^{14}. Notice how the percent remaining declines by 50% with each half-life.

13) **__Ion-__** an atom or molecule that has either gained or lost an electron(s); and as a result has either a positive or negative charge.
  a) **__Cation-__** a positively charged ion.
    i) A former student once remembered this by noticing that if you add a "u", it spells caution (Ca**u**tion). And, you should exercise caution around positively charged wires.
  b) **__Anion-__** a negatively charged ion.
    i) Remember: A (A) / n (negative) / ion (ion)

If all atoms have negatively charged electrons, shouldn't every sample of matter have a negative charge? No Why not? Because positively charged protons off set the negative charge of the electrons. And, unless it is an ion, it has the same number of protons as electrons.

Atomic Structure.

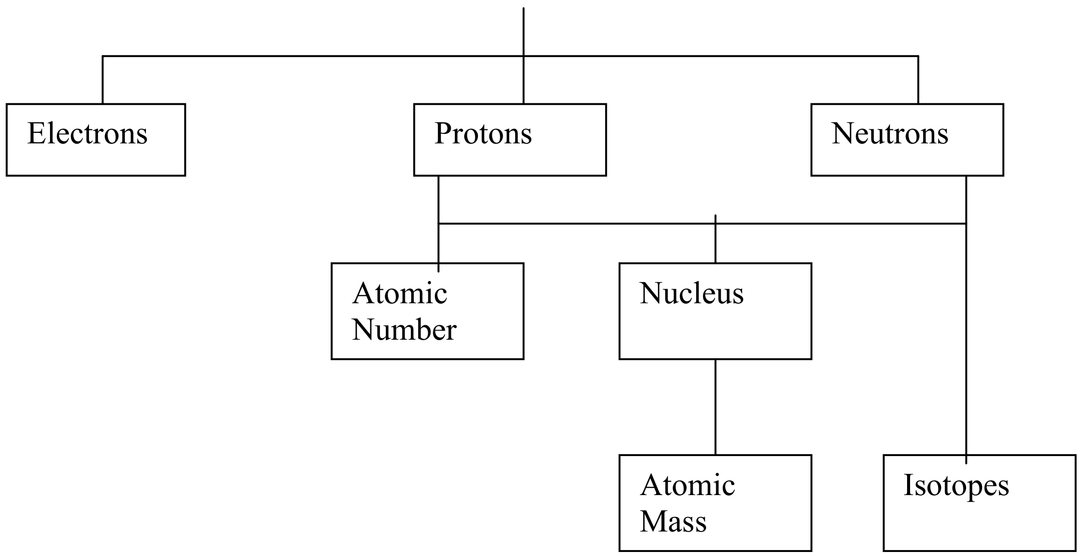
14) Remember: the following applies to the most abundant isotope, the one indicated on the periodic chart.

a) Atomic number = # of protons = # of electrons (in a neutral atom)

b) Atomic mass = Sum of the protons (atomic number) + # of neutrons

c) Examples: When given the **bold** print information, fill in the remaining information (answers in red).

Element Symbol	Atomic Number	Atomic Mass	# of Protons	# of Electrons	# of Neutrons
Ca	20	40	20	20	20
Br	35	80	35	35	45
C^{14}	6	14	6	6	8
Na	**11**	23	11	11	12
F	9	**18**	**9**	9	9
S^{-2}	16	32	**16**	**18**	16
Cl^{-}	17	35	17	18	18
Ag^{+}	47	108	47	46	61
Ba^{140}	56	140	**56**	56	**84**


Electrons
Protons
Neutrons
Atomic Number
Nucleus
Atomic Mass
Isotopes